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Reducing Power Waste in Operating Cotton Gins [1]

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INTRODUCTION

The reduction of waste of power in commercial gins is one of the main factors in lowering the operating cost of ginning. This is of vital importance to the ginning industry today, because the competition is so keen that the waste of power may mean the difference between a profit and loss to the ginner. It is the responsibility of the ginner himself to trace the waste of power in a gin to its source and take steps to eliminate it.

With the increased use of electric- and Diesel-operated gins, this problem of wasted power has been brought to the attention of ginners more during recent years than heretofore. Most of the old gins used steam power units which were large enough to take care of any excessive power loads without materially affecting the power costs. However, with the modern electric- or Diesel-powered gin, the ginner pays for the actual quantity of energy consumed. As a result, an increasing number of requests from ginners for power surveys, advice, and assistance have been received by the United States Cotton Ginning Laboratory and by the power companies. In most instances, where it

[1] Credit is due Charles A. Bennett, senior mechanical engineer, Bureau of Agricultural Chemistry and Engineering, and Francis L. Gerdes, senior cotton technologist, Agricultural Marketing Service, for supervision and suggestions, and to coworkers in both agencies for their assistance.

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was possible to follow up these requests, the difficulty was traceable to improper piping lay-outs, leaky pipes, excessive separator leaks, and improper fan operation. Sometimes, the fault was found in the use of excessive doffing pressures on air-blast gins, leaky air-line cleaners, the handling by fans of a greater volume of air than necessary, the use of excessive overhead cleaning equipment, and improper drier installations. Many gins operate with a large fan doing both cotton unloading and seed or trash blowing; and, in most cases, the pipe sizes are not correctly proportioned, thereby making unbalanced systems. Neither cotton suction nor seed blowing should require excessive power if done with individual fans, because the proper fan speeds and velocities in each case can be obtained.

As part of the research program of the United States Cotton Ginning Laboratory, a power survey was made at 63 representative gins in the Yazoo-Mississippi Delta in Mississippi and in nearby States during the 1938 and 1939 ginning seasons. This survey included power readings at 31 typical air-blast gins and 32 brush gins. Twenty-six of these gins were equipped with seed-cotton driers. The gins surveyed consisted of 22 three-stand outfits, 33 four-stand outfits, and 8 five-stand outfits. The fans included in this survey were 11 regular suction fans, 10 Rembert-type suction fans, 41 combination suction and seed-blowing fans, 26 drier fans, 31 air-blast fans, and 40 hull and trash fans. All of these varied considerably in size, speed, type, and model, representing a wide range of field conditions for fan performance.

The power readings made in this survey showed that about 40 percent of the power used for ginning was consumed by fans and 60 percent by the gin stands, separators, feeders, cleaners, presses, and other equipment. These percentages for fan power ranged from 19 to 64 for all gins. The average horsepower requirements per stand were as follows: Air-blast fans, 4.7; suction and seed-blowing fans, 5.7; regular suction fans, 4.6; Rembert-type unloading fans, 5.3; seed-blowing fans, 3; drier fans, 3.6; and hull fans, 1.3.

The above average power figures show the general situation as regards the power consumed by gins. However, each gin has its own problem of modernization as shown by the range of figures throughout this bulletin. It is desirable to make savings, even though small, in the numerous items in a gin set-up, because the total is frequently significant.

ASCERTAINING THE POWER CONSUMPTION

In 1935, there were reported for the United States, 5,779 steam gins; 3,102 Diesel; 1,793 gins using natural gas or gasoline; 3,307 electric gins; and 261 water-power gins.[2]

To determine the motive power for electrically operated gins, it is essential to know the ratio of the current transformers to the motors.[3] These ratios vary with each gin and must be obtained from the power company or someone familiar with that set-up. In some gins the

[2] Based on reports of the U. S. Bureau of the Census. COTTON GINNING MACHINERY AND EQUIPMENT BY STATES, 1935 [Multilithed.]

[3] BENNETT, CHARLES A., and GERDES, FRANCIS L. COTTON GIN OPERATING AND TESTING EQUIPMENT. U. S. Dept. Agr., 14 pp., illus. 1939. [Mimeographed.]

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power company marks this ratio or constant (K) on each meter at the time installation is made, thus making it very simple to determine the power.

The general formula for computing horsepower is:

$$\frac{3{,}600 \times 0.6K \times \text{number of revolutions of disk}}{\text{Number of seconds} \times 746}$$

For example, if the constant, K, for an installation is 80, and the disk on the meter makes 10 complete revolutions in 38½ seconds, the results would be:

$$\frac{44,883}{746} = 60.2 \text{ horsepower}$$

The constant K in the formula is the ratio of the current transformers to the meter for that installation. The 0.6 is a ratio that plies only to the meter itself, for 110-volt current. It is $1.2K$ if the rent is 220 volts and $2.4K$ if 440 volts are used. These voltages ly to the meter only, but most installations utilize 110-volt meters n if the voltage on the gin motor is 220 or 440.

The common method for determining the motive power for internal bustion engines is to obtain the weight of the fuel consumed by the ne over a definite period of time. In running these tests, the main supply line to the engine is cut off, and, at some place on the engine ided by the manufacturer, the fuel is poured in and the engine ed to run for a definite length of time. At the end of the run, the weight of the fuel is recorded and from the power curves of the manufacturer the brake horsepower can be determined.

To determine the power of a steam engine, it is essential to have a steam indicator which connects to the steam cylinder and records the steam pressure against the piston on a chart. From the cross-sectional area, in square inches of the piston, A, the length of stroke, L, in feet, the number of revolutions of the engine per minute, N, and the mean effective pressure in pounds per square inch, P, the horsepower can be determined by substituting in the formula $\frac{PLAN}{33,000}$, in which 33,000 is the number of foot-pounds of work per minute in 1 horsepower.

The air horsepower required to operate a fan is determined from the quantity of air the fan is moving and the resistances the fan is operating against. The two fundamental readings to be made are:

(1) P_v, which is the velocity head from which is determined velocity and volume of air moving through the pipe.

(2) P_s, the static pressure or resistance which the piping and the entire system offer to the flow of air.

These readings are all expressed in inches of water pressure.

The two essential instruments used in making air readings on a fan are the pitot tube and the manometer. The pitot tube, details of which are shown in figure 1, is inserted in the center of the pipe and connected to the manometer as shown in figure 2, A, and the P_v is read on the manometer in inches of water pressure. The velocity

pressure (P_v) readings may be made either in the suction or discharge side of the fan but should be taken in a straight run of piping of not less than 7½ diameters, because it requires that much of a straight run to eliminate the effects of eddy currents caused by irregularities in the piping. By means of velocity pressure readings and volume calculations for various places in the piping lay-out, the air losses can readily be traced to their source. Static readings are used to show

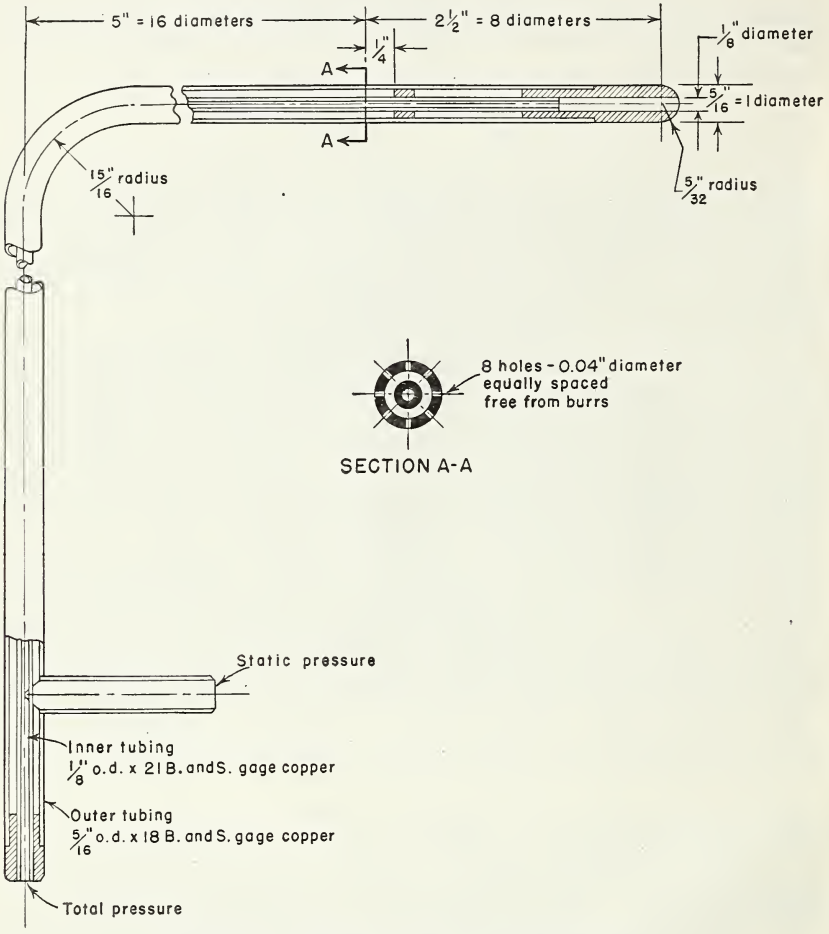

FIGURE 1.—Details of pitot tube construction.

the resistance to the flow of air offered by the system, which includes the piping, separators, and other auxiliary equipment. Such readings can be made anywhere in the system to determine the individual resistance offered by each piece of equipment and its piping. A high degree of accuracy cannot be obtained in readings made at cotton gins, but the readings here given are believed to be accurate enough for practical purposes.

Refined corrections to standard air and the like have not been incorporated in these calculations.[4] The greatest resistance (P_s) used in computing the horsepower for the fan is obtained by making the readings as shown in *B*, *C*, and *D*, figure 2. The sum of the static and velocity pressures is called the total pressure (P_t) and is used in the formula for calculating the air horsepower. With these readings, it is possible to determine the velocity, volume of the air in the pipe, and the air horsepower of the fan. The velocity is equal to $3{,}650\times\sqrt{P_v}$ and is expressed in feet per minute.[5] The volume is equal to the product of the velocity times the cross-sectional area of the pipe in square feet, and is expressed in cubic feet per minute.

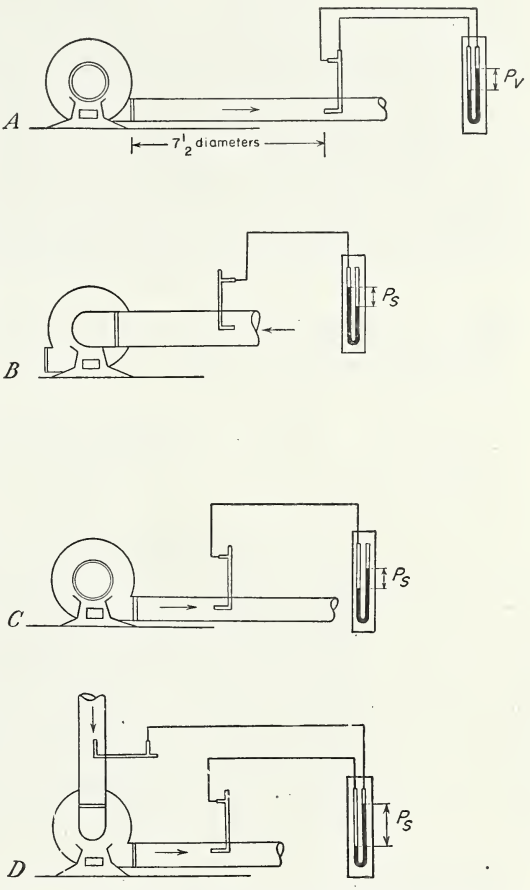

FIGURE 2.—Diagram illustrating the use of a pitot tube and manometer in making air readings: *A*, Velocity pressure (P_v); and *B*, *C*, and *D*, static pressure (P_s); for fans used for suction only (*B*); for blowing only (*C*); and for both suction and blowing (*D*).

The air horsepower of a fan can then be derived by the use of the formula $\frac{\text{Volume}\times P_t}{6{,}350}$. The air horsepower is the power required to operate a fan having 100 percent efficiency. The actual or brake horsepower is then obtained by multiplying the theoretical horsepower by an efficiency factor. Tests at the Cotton Ginning Laboratory have shown that it will be sufficiently accurate for field use in determining the approximate horsepower to multiply the theoretical horsepower by three for Rembert-type fans and by two for the other commonly used gin fans.

Since the rise in the temperature of air going through a fan is due to heat of compression and is a measure of the amount of work done by the fan, it can be utilized in calculating the actual or brake horse-

[4] ENGINEERING COMMITTEE, NATIONAL ASSOCIATION OF FAN MANUFACTURERS, AND FAN TEST CODE COMMITTEE, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. STANDARD TEST CODE FOR CENTRIFUGAL AND AXIAL FANS. Ed. 3, Natl. Assoc. Fan Mfrs. Bul. 103, 22 pp., illus. 1938.

[5] BENNETT, CHARLES A. SIMPLIFIED PITOT TUBE CALCULATION OF AIR FLOW IN DUCTS AND PIPES. 4 pp., illus. 1936. [Mimeographed.]

power. This is an alternate method for determining fan horsepower and is satisfactory. Table 1 gives the horsepower on a fan shaft for moving 1,000 cubic feet of air per minute so that, by multiplying the volume of air in 1,000-cubic-foot units handled by the fan by the appropriate figure in the table based on the temperature rise, the horsepower is obtained. The brake or actual horsepower thus obtained takes into consideration the fan efficiency. In table 2 under the appropriate static head pressure, the efficiency for fans for any given horsepower can be determined by referring to column 1. For example, if a fan is moving 3,500 cubic feet of air per minute against a static pressure of 12 inches and the inlet temperature is 90° F., and the outlet temperature is 100°, the horsepower required per 1,000 cubic feet of air is 4.24 (table 1), or $3.5 \times 4.24 = 14.8$ horsepower for 3,500 cubic feet of air. The efficiency of the fan is then obtained by referring to table 2 under the column headed 12 inches of pressure and following down to 4.24, opposite which the efficiency of the fan is about 45 percent as indicated in the left-hand column.

TABLE 1.—*Actual horsepower used to operate a fan for delivering 1,000 cubic feet of air per minute when the volume of air handled and the temperature rise of the air going through a fan are given* [1]

Temperature rise [2] (° F.)	Horsepower required to deliver 1,000 cubic feet of air per minute for specified air-inlet temperature into fan (T_1)—												
	40° F.	45° F.	50° F.	55° F.	60° F.	65° F.	70° F.	75° F.	80° F.	85° F.	90° F.	95° F.	100° F.
	Hp.	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*
1	0.47	0.46	0.46	0.45	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42
2	.93	.92	.91	.91	.90	.89	.88	.87	.86	.85	.84	.84	.83
3	1.40	1.39	1.37	1.36	1.35	1.34	1.32	1.30	1.29	1.28	1.27	1.26	1.25
4	1.87	1.85	1.84	1.82	1.80	1.78	1.76	1.75	1.73	1.71	1.70	1.68	1.66
5	2.33	2.31	2.29	2.27	2.25	2.23	2.20	2.18	2.16	2.14	2.12	2.10	2.08
6	2.80	2.78	2.75	2.73	2.70	2.68	2.65	2.63	2.60	2.58	2.55	2.53	2.50
7	3.27	3.24	3.21	3.18	3.15	3.12	3.09	3.06	3.03	3.00	2.97	2.94	2.91
8	3.74	3.70	3.67	3.63	3.60	3.56	3.53	3.50	3.46	3.43	3.40	3.36	3.33
9	4.20	4.16	4.12	4.08	4.05	4.01	3.97	3.93	3.89	3.86	3.82	3.78	3.74
10	4.67	4.62	4.58	4.54	4.49	4.44	4.40	4.36	4.32	4.28	4.24	4.20	4.16
11	5.14	5.09	5.04	5.00	4.95	4.90	4.85	4.80	4.75	4.70	4.66	4.62	4.57
12	5.61	5.56	5.50	5.44	5.39	5.34	5.28	5.23	5.18	5.13	5.08	5.03	4.98
13	6.07	6.02	5.96	5.90	5.85	5.79	5.73	5.67	5.61	5.56	5.50	5.45	5.40
14	6.54	6.48	6.42	6.36	6.30	6.24	6.18	6.12	6.05	6.00	5.94	5.88	5.83
15	7.00	6.94	6.88	6.81	6.75	6.68	6.62	6.55	6.48	6.42	6.36	6.30	6.23
16	7.48	7.41	7.34	7.27	7.20	7.13	7.06	6.99	6.92	6.85	6.79	6.72	6.66
17	7.93	7.86	7.79	7.72	7.65	7.58	7.50	7.42	7.35	7.28	7.21	7.14	7.07
18	8.41	8.33	8.25	8.17	8.09	8.01	7.93	7.85	7.78	7.70	7.63	7.56	7.49

[1] Acknowledgment is made to F. P. Grutzner, Fairbanks Morse & Co., for basic formulas and table from which the above table has been prepared.

[2] $T_2 - T_1$. T_1 is the air-inlet temperature and T_2 is the air-outlet temperature.

TABLE 2.—*Horsepower on fan shaft for delivering 1,000 cubic feet of air per minute for specified fan efficiency and pressure differences*[1]

Fan efficiency (percent)	Horsepower required to deliver 1,000 cubic feet of air per minute for specified pressure differences P_s through the fan in inches of water—																	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Hp.	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*
25	1.26	1.89	2.52	3.15	3.78	4.41	5.04	5.67	6.30	6.92	7.55	8.14	8.72	9.41	10.10	10.72	11.35	11.98	12.60
30	1.05	1.58	2.10	2.62	3.15	3.68	4.20	4.72	5.25	5.78	6.30	6.82	7.35	7.88	8.40	8.92	9.45	9.98	10.50
35	.90	1.35	1.80	2.25	2.70	3.15	3.60	4.05	4.50	4.95	5.40	5.85	6.30	6.75	7.20	7.65	8.10	8.55	9.00
40	.79	1.18	1.58	1.97	2.36	2.76	3.15	3.54	3.94	4.33	4.72	5.12	5.51	5.90	6.30	6.69	7.08	7.48	7.88
45	.70	1.05	1.40	1.75	2.10	2.45	2.80	3.15	3.50	3.85	4.20	4.55	4.90	5.25	5.60	5.95	6.30	6.65	7.00
50	.63	.94	1.26	1.58	1.89	2.20	2.52	2.83	3.15	3.46	3.78	4.10	4.41	4.72	5.04	5.36	5.66	5.98	6.30
55	.57	.86	1.14	1.43	1.72	2.00	2.29	2.58	2.86	3.15	3.44	3.72	4.01	4.30	4.58	4.87	5.15	5.44	5.73
60	.52	.79	1.05	1.31	1.58	1.84	2.10	2.36	2.62	2.89	3.15	3.41	3.67	3.94	4.20	4.46	4.72	4.99	5.25
65	.48	.73	.97	1.21	1.46	1.70	1.94	2.18	2.42	2.66	2.91	3.15	3.39	3.63	3.88	4.12	4.36	4.60	4.84
70	.45	.68	.90	1.13	1.35	1.58	1.80	2.03	2.25	2.48	2.70	2.93	3.15	3.38	3.60	3.83	4.05	4.28	4.50
75	.42	.63	.84	1.05	1.26	1.47	1.68	1.89	2.10	2.31	2.52	2.73	2.94	3.15	3.36	3.57	3.78	3.99	4.20
80	.39	.59	.79	.98	1.18	1.38	1.58	1.77	1.97	2.16	2.36	2.56	2.76	2.95	3.15	3.35	3.54	3.74	3.92
90	.35	.52	.70	.88	1.05	1.22	1.40	1.58	1.75	1.92	2.10	2.28	2.45	2.62	2.80	2.98	3.15	3.32	3.50
100	.32	.47	.63	.79	.94	1.10	1.26	1.42	1.58	1.73	1.89	2.05	2.21	2.36	2.52	2.68	2.83	2.99	3.15

[1] Acknowledgment is made to F. P. Grutzner, Fairbanks Morse & Co., for basic formulas and table from which the above table has been prepared.

PIPING LAY-OUTS

For a fan to operate most economically it is necessary that all piping connections, draw bands, and adapters are well sealed to eliminate air leaks. Since a suction line usually has two or three valves, as well as many joints and elbows, it can readily be seen how the loss in air around these will increase the load on the fan. An efficient piping lay-out must be of a proper size and as free as possible from obstructions, abrupt bends, and unnecessary curves. Surveys have shown that as much as 40 percent of the air handled by the seed-blowing fan is often lost in the seed dropper and seed line if not well sealed.

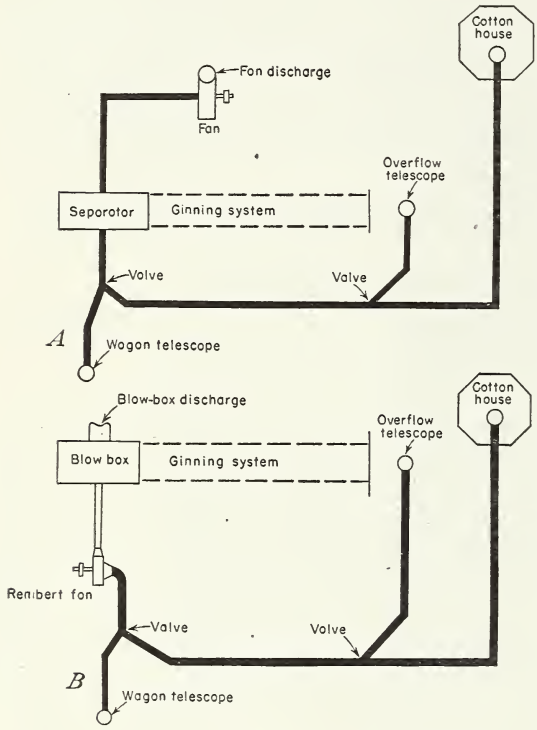

FIGURE 3.—Diagrams of typical cotton-gin piping systems: *A*, For a separator set-up; *B*, for a Rembert fan and blow-box set-up.

The average suction pipe diameters in the 63 gins surveyed were 11.7 inches for three-stand, 12.3 inches for four-stand, and 13 inches for five-stand gins. Laboratory tests, however, have shown that the air velocity at the telescope should be from 3,500 to 4,000 feet per minute in suction pipes of 9 to 10, 10 to 11, and 11 to 12 inches, which are sufficient to supply three-, four-, and five-stand gins, respectively. The corresponding power to supply sufficient cotton for three-, four-, and five-stand gins was 5.8, 8, and 11.4 horsepower when a 50-foot suction with free discharge was used (table 3). The set-up involving the 150-foot suction and free discharge increased the corresponding horsepower requirements to 12.8, 15.9, and 17.2, respectively, for three-, four-, and five-stand gins. On the basis of these figures for each 10-foot addition of pipe, an addition of 0.6 to 0.8 horsepower is required to handle the cotton. The importance of keeping the length of the suction pipes to a minimum can readily be seen from these figures.

Since most suction fans have to convey the cotton not only from the wagon to the ginning system but also from the cotton house, the piping lay-out should be designed to give the same friction loss and constant volume from the cotton house as from the wagon telescope.

In such a system, the wagon suction velocity may have to be stepped up to balance the added piping to the cotton house.

Diagram plans of piping for two systems are shown in figure 3. In these systems, the wagon and overflow telescopes may be the same size, but where cotton-house suction and overflow employ the same piping in part, the cotton-house line should be continued to the separator without reduction in size. The sizes of the line at the secondary valve for the overflow connection and at the wagon-suction take-off should be reduced. Valves in all seed-cotton suction lines should be placed in a vertical position, if located at separator inlet, to prevent unequal distribution of seed cotton into the separator, and the piping from the separator to the fan should be preferably three-eighths to one-half of the fan-wheel diameter, without reduction into the fan inlet. The piping should be smooth and have no low spots where seed cotton or cotton seed might be trapped. The shortest and most direct piping lay-out is the best because the amount of power required in moving cotton is proportional to the distance through which it is moved.

TABLE 3.—*Performance data for standard fans and separator set-ups with a suction of 4,000 feet per minute at the telescope* [1]

Suction pipe length (feet)	Diameter of pipes		Volume of air handled per minute at—		Total resistance pressure	Power required	Velocity of air per minute on discharge [2]
	Suction	Discharge	Telescope	Fan inlet			
	Inches	*Inches*	*Cubic feet*	*Cubic feet*	*Inches*	*Horsepower*	*Feet*
50	10	[3]	2,180	3,406	4.4	5.8	[3]
	11		2,639	3,825	4.6	8.0	
	12		3,140	4,486	5.9	11.4	
	13		3,685	5,047	6.8	14.9	
150	10	[3]	2,180	3,758	8.2	12.8	[3]
	11		2,639	4,188	8.4	15.9	
	12		3,140	4,906	8.6	17.2	
	13		3,685	5,583	10.0	19.4	
200 [4]	10	10	2,180	3,406	13.0	14.4	6,250
		11			11.0	12.4	5,161
		12			9.8	8.8	4,334
	11	10	2,639	3,825	15.8	18.9	6,900
		11			12.5	15.7	5,771
		12			10.3	13.1	4,869
	12	10	3,140	4,486	18.9	23.8	8,225
		11			15.6	20.8	6,800
		12			13.3	18.9	5,712

[1] These average figures are based on the performance of 3 fans in the ginning laboratory for each specified set-up.
[2] For seed blowing, air velocities of approximately 5,000 to 5,500 feet per minute are usually necessary.
[3] Free.
[4] 50-foot suction, 150-foot discharge.

Observations made by the authors with respect to piping in commercial gins, and supporting data obtained from the survey show that in most gins elbows in pipe lines can be replaced with less abrupt bends, or eliminated entirely. A 90° elbow in the piping is approximately equivalent in resistance to a 10-foot straight length of piping. While offsets are often necessary in piping layouts; their ill effects can be minimized if they are properly spaced. Where elbows are used they should be placed as far as possible from the separator, fan inlet, or other equipment which they are to serve, because of their tendency to throw the cotton to one side of the unit and cause chokages.

REDUCING SEPARATOR LOSSES

Separators constitute a main source of power waste, especially when badly worn or having leaky connections. Even new and well-sealed separators have a significant intake of air through the vacuum wheel.

From the survey made of 14 gins where the separator loss was 35 percent or more, and averaged 42.7 percent, the power required to operate the suction and seed-blowing fan was 27.6 horsepower for a four-stand gin. In a similar group of 18 gins showing separator losses of less than 35 percent and averaging 27.3, the corresponding horsepower requirements amounted to 19.2 for the four stand gin. In other words, with the reduced leakage in the separator and piping from an

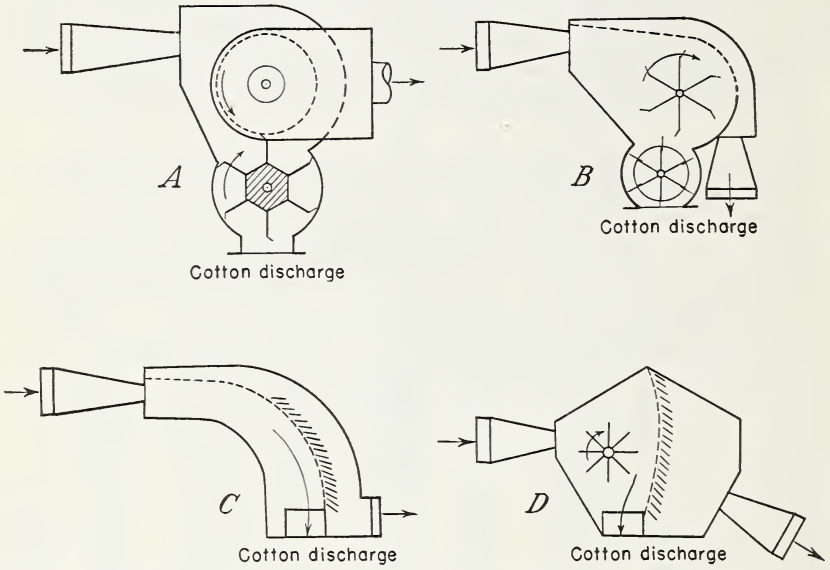

FIGURE 4.—Various types of separators: *A* and *B*, New improved types; *C* and *D*, obsolete types.

average of 42.7 to one of 27.3 percent, a saving of 8.4 horsepower could be accomplished.

Improved forms of separators now on the market employ revolving screens and vacuum wheels which handle the cotton with lower air losses and fewer chokages than the older types. To obtain an air seal, the use of revolving vacuum wheels, as shown in figure 4, *A* and *B*, in connection with the separators is superior to using a belt distributor with solid flaps, as shown in figure 4, *C* and *D*.

Reduction in leakage requires continued upkeep, inspection, and repair of the separator.

REPLACING SEPARATOR WITH REMBERT UNLOADING SYSTEM

Many modern gin installations have eliminated the separator entirely by installing a Rembert-type fan, discharging the cotton into a blow box or 30° angle screen box (fig. 5). Extensive laboratory

and field tests have shown that the Rembert-fan method of unloading seed cotton from the wagon and feeding it to a cleaner or distributor

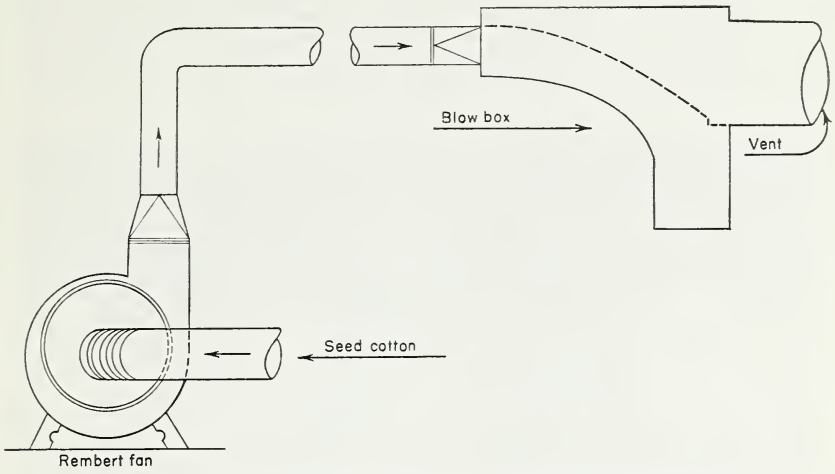

FIGURE 5.—Diagram showing Rembert fan and screen blow box.

is practicable and is more economical in operation than the customary standard fan and separator arrangement. Comparative tests of these

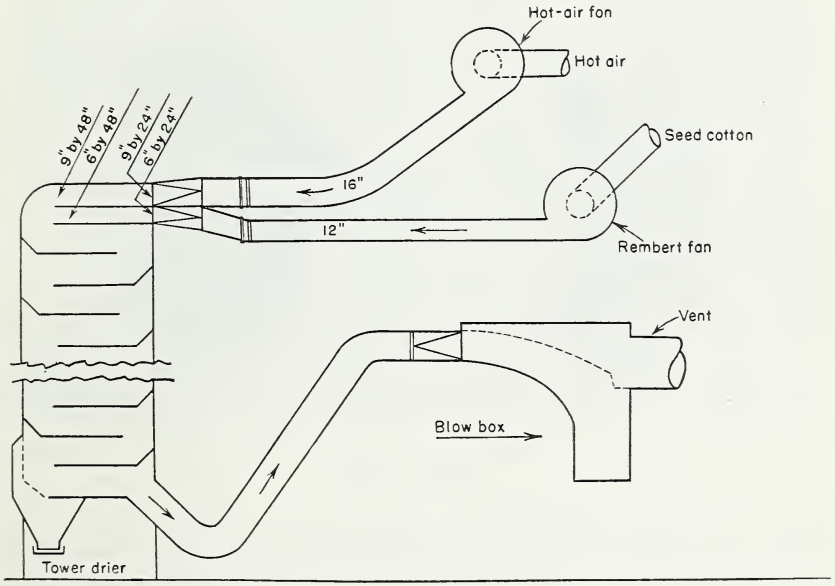

FIGURE 6.—Drier installation using a Rembert fan and Y-system in conjunction with a screen blow box.

methods of unloading seed cotton indicated very definitely that there is no difference in the quality of lint ginned from seed cotton handled by the two methods. The savings in power were evident because

with the Rembert fan, all of the air handled by the fan was employed in unloading the cotton while, with the other system, the fan had to run at a higher speed or be of a larger size and handle more air to provide as good a suction as the Rembert system because of separator losses. This method of unloading is especially adaptable to tower-drier installations where the hot air and cotton are mixed in a wye and blown through the drier as shown in figure 6. Surveys made at

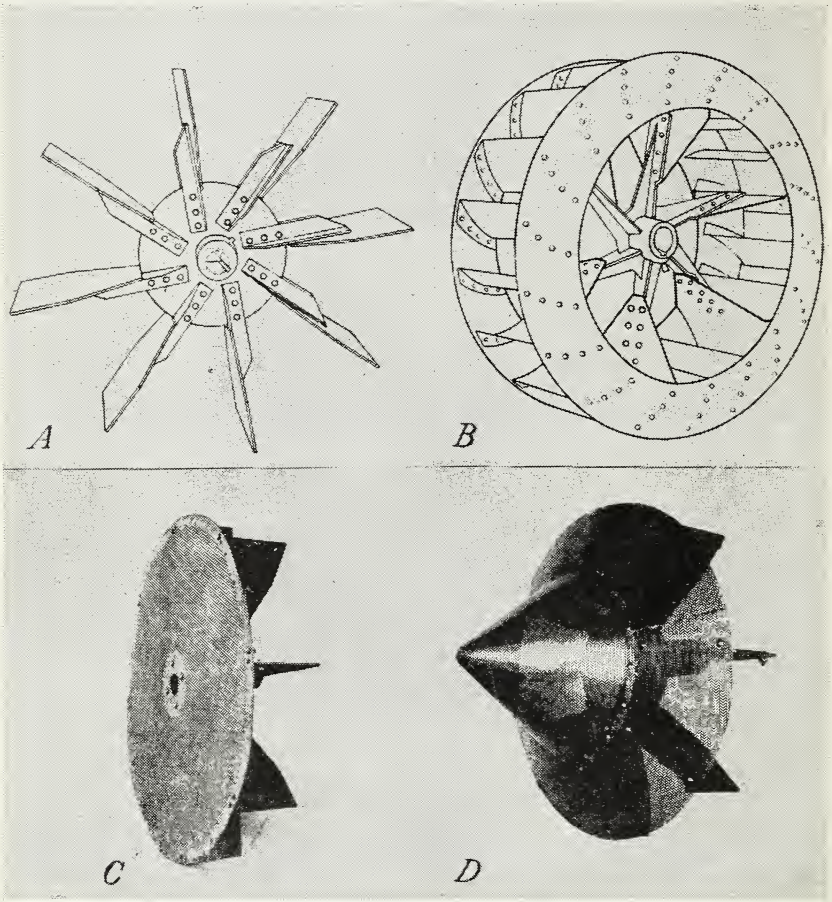

FIGURE 7.—Fan wheels: *A*, Plain; *B*, shrouded; *C*, flat Rembert-type; *D*, cone Rembert-type.

commercial gins employing the Rembert-type fan in combination with a drying fan in Y-system set-ups showed that in a four-stand gin the average fan power for handling and drying the cotton amounted to 30.8 horsepower. In a corresponding set-up where a suction fan and separator were used to handle the cotton in combination with a drying fan, the required horsepower was 32.8, not including the power required to operate the separator which ranges from 2 to 5 horsepower.

Fan wheels that have no side plates or shrouds (fig. 7, *A*) are called plain wheels. Fan wheels designed for greater efficiency or

for special purposes are frequently provided with shrouds as shown in figure 7, *B*. Some installations eliminate the separators by making use of flat Rembert-type wheels (fig. 7, *C*) in which the perforated steel disk fastened to the side of the wheel prevents the cotton from passing through the blades of the fan. A more recent development by the Cotton Ginning Laboratory is a cone-shaped Rembert fan which is proving to be more efficient than the flat-disk type (fig. 7, *D*). The tests at the laboratory have shown that the efficiency of this fan is 44 percent as compared to 35 percent for the standard Rembert-type, under the same operating conditions. Several of these fans are now being run at commercial gins in the Mississippi Delta. In addition to the increased efficiency of cone Rembert-type wheels over the flat-disk Rembert, tests have shown that the cone-type Rembert does not tend to crack the seed as much as the flat disk especially when handling dry cotton at high velocities.

FANS

Correct Fan Speeds

In many instances fans in gins are run faster than is necessary. Since the capacity of a fan varies directly with its speed, pressure varies with the square of the speed, and the power used varies with the cube of the speed, it can readily be seen how important it is to keep the fan speed at a minimum and in line with the manufacturer's recommendations.

A series of tests performed at the laboratory showed that the quantity of cotton handled depends on the pipe size and that suction velocities from 3,500 to 4,000 feet per minute are adequate. Air readings made at the gins in the survey showed that 38 percent of the suction fans were moving air at the rate of 4,000 or more feet per minute at the telescope, and that some ginners are moving air at the rate of 6,300 feet per minute. In such cases considerable saving in power could be effected by slowing the fans.

Air-blast fans can be another source of power waste if operated at excessive speeds or without some convenient means of controlling the quantity of air handled. For efficient doffing, air-blast gins require nozzle pressures of 9 to 14 inches depending on the moisture content of the cotton. Many ginners overload their air-blast fan by maintaining a higher nozzle pressure than is necessary for effective doffing, as shown in the survey where these pressures ranged from 9 to 19 inches water pressure. Out of the 31 air-blast fans in the survey, 16 were operating with nozzle pressures over 14 inches water pressure, averaging 16.1 inches, and the fans were using an average of 21.5 horsepower for the four-stand outfits. On the gins operating with nozzle pressures less than 14 inches and averaging 12.6 inches, the power required for the fans averaged only 16.6 horsepower for the four-stand outfits, or a difference of 4.9 horsepower in favor of fans operating at a proper doffing pressure.[6]

Few commercial gins are equipped with variable-speed units or other convenient means for reducing fan speeds to regulate the volume of air needed for the task required of them. A valve on the intake

[6] Johnson, Arvid J., and Baggette, Thomas L. air-blast gin performance and maintenance. U. S. Dept. Agr. Cir. 510, 18 pp., illus. 1938.

side of the fan similar to the one shown in figure 8 offers an economical and practical means for changing the volume of air without changing the speed of the fan.

A slide damper of the type shown in figure 9 will achieve substantially the same results as the cone type if it is placed at a distance of at least four pipe diameters from the inlet.[7] For use on an air-blast fan, a convenient water-gage installation for checking nozzle pressures is shown in figures 8 and 9.

In selecting a fan to perform a certain task it should be kept in mind that undersized fans, operated at excessive speeds, generally are less desirable than fans of ample size operated at moderate speeds,[8]

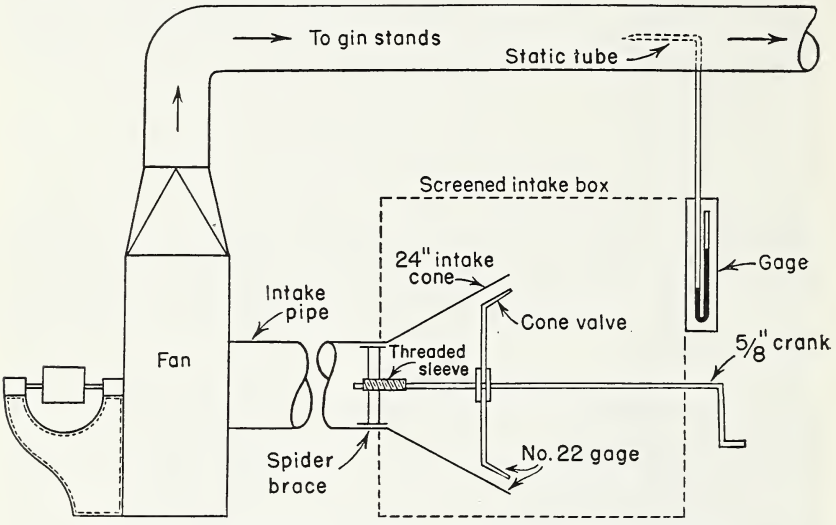

FIGURE 8.—Government-design cone-type fan-intake control.

and that intake valves or dampers (except for Rembert-type fans) provide a feasible method of adjusting the volume where the speed cannot be conveniently reduced.

PROPER SIZE AND DESIGN OF FANS

Volume and pressure characteristics of gin fans differ so much for different makes that it is desirable to consult the manufacturers for specific performance information.

The selection of a fan should be governed by the required air volume and system pressure as well as by the general purpose for which it is to be used. Although seed cotton or cottonseed should not be permitted to pass into the scrolls or wheels of standard fans, the use of Rembert-type fans is permissible.

Rembert-type fans are frequently employed in cotton conditioners as well as at cotton houses for unloading seed cotton from wagons to

[7] See footnote 6.

[8] BENNETT, CHARLES A., and GERDES, F. L. GINNING COTTON. U. S. Dept. Agr. Farmers' Bul. 1748, 46 pp., illus. 1935.

——— BAGGETTE, T. L., and GERDES, F. L. MODERNIZING COTTON GINS. U. S. Dept. Agr. Farmers' Bul. 1802, 52 pp., illus. 1938.

storage bins, but only recently have such fans been used to replace separator fans and standard fans.

Housings for fans should be of the universal kind so that the fans may be used either right or left hand and be adjustable to at least eight positions. Rembert-type fans, however, must be chosen for either right- or left-hand operation depending on the location of the installation. For continuous economical service, ball bearings or roller bearings should be used on fans.

Limiting the Duty of Fans

Improvement in fan design as well as improved handling systems and cotton piping make it possible, in some instances, to reduce the number of fans in a set-up, or to use the same fan at different times for more than one purpose. Rembert-type fans can also frequently be used for more than one purpose. For instance, one can be used during ginning for unloading in connection with pneumatic elevators or a mechanical separator and, during other periods, as a cotton-house unloader, by using a bypass valve around the elevator or separator. In a gin with a drier a Rembert fan can be made to serve the drier and also for delivering the cotton to the bins or transferring it from one bin to the other.

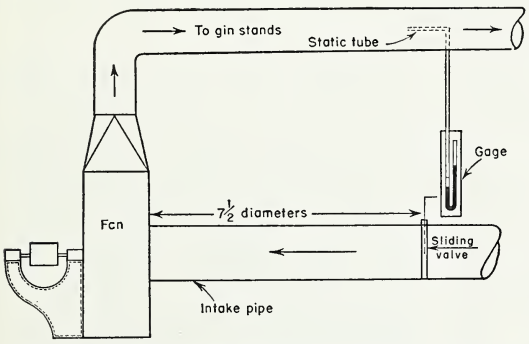

Figure 9.—Slide damper-type of fan-intake control.

In many ginneries it is possible to eliminate the seed-blowing fan by using a belt or screw conveyor to perform this task, since it is not desirable to blow seed with the discharge volume from a cotton suction fan. However, trash may be handled by the cotton fan discharge if not put directly through the fan. This is successfully done in some instances with a rotary feeder, and in others with a "syphon" Y which drops the trash into the outgoing air stream.

Care of Fans

Worn wheels and scrolls constitute a hazard and a power loss. Defective wheels should be replaced with new ones properly balanced. The selection of a new wheel may be influenced by the amount of wear introduced by grit, sand, and dust, so that slightly better power features may be offset by a necessity for sturdier, though less efficient, construction. Substitute wheels for hulls and trash are therefore usually of the paddle-wheel type.

Casings or scrolls may, in some instances, be lined to prolong their life, but this depends upon the service for which the fan is used.

If sand and other cutting materials are to be handled continuously in the air volume, the fan scroll should be of cast iron. Under such

operating conditions both wheels and scrolls should be fully inspected at frequent intervals, and Rembert-type disks should be thoroughly examined.

EMPLOYING MORE EFFICIENT METHODS OF HANDLING SEED

Seed and trash may be handled by various methods, such as gravity, belts, screw conveyors, and pneumatic piping. Conveying the seed entirely by air with piping of improper size and containing leaks, is frequently more expensive than by other methods. Various means for economically handling seed have been devised, the more common of these being the blowpipe-vacuum system under the gins, with connection to a fan handling clean air, and the belt system under the gins for feeding pure seed to sacks in the gin house, or to the blow system to the seed house. In two-story gins, screw conveyors can be converted to acceptable seed-saving devices by hinging the bottom so that it can be dropped to permit thorough cleaning of the conveyor box, auger, and hangers.

When the discharge from the suction fan is utilized for seed blowing, the power to operate the fan necessarily increases. Tests have shown that to economically balance such a fan, it will have to be operated so as to produce a suction velocity of 3,500 to 4,000 feet per minute, and a velocity of 5,000 to 5,500 feet per minute in the seed line. The average fan power for 15 gins in the survey was 26.6 horsepower where the air velocity in the seed-blowing line was 5,500 feet per minute or more; the separator loss in volume was 37.5 percent, and the average suction velocity was 4,227 feet per minute. The average power required by fans in 16 other similar set-ups was 18 horsepower where the air velocity was less than 5,500 feet per minute in the seed-blowing line. The separator loss in volume was 31.1 percent and the corresponding suction velocity was 4,653 feet per minute. The excessive power used in the former group may be attributed to excessive leaks in the system, and to handling more air than is necessary to perform a required task. Results from the survey of power requirements for 13 typical seed-blowing fans used in four-stand gins showed that for 7 of the gins using seed-blowing lines of 11 inches or less, the average horsepower was 9.2, as compared with an average of 14.4 for the other 6 gins, having seed-blowing lines larger than 11 inches.

It is highly desirable to use separate fans for suction and seed conveying. When the discharge from the suction fan is used to convey the seed, it is very likely to contaminate the seed with foreign matter from the cotton, thus lowering the quality of the seed. Sometimes excessive seed-blowing velocities are maintained in order to obtain required suction velocities because of leaky separators or bad connections. Where one fan for suction and one for seed blowing is used, more efficient piping sizes can be utilized because it will not then be necessary to step up the volume used for suction to maintain the required velocity in the seed-blowing line.

Recent preliminary tests conducted at the laboratory where a small rotary air pump was used to convey seed through a 4-inch

pipe showed that 100 pounds of seed per minute could be moved with 5½ horsepower. In this type of seed conveying, it is important to select a vacuum-type seed dropper which permits perfect sealing and introduces the seed directly into the stream of air.

ANTIFRICTION BEARINGS AND V-BELTS

All shafting and bearings are a source of power waste, and ball bearings or roller bearings should be substituted wherever possible for plain or ring-oiling bearings because they not only require less power but less attention, much less lubricant, and are less subject to wear. All bearings must be carefully guarded against damage from grit and dust, and approved dust-sealed, good-quality commercial types designed for such service should be selected. Only seasonal attention and lubrication are necessary for good ball bearings, and the costs of lubrication are thus low. Good alinement of shafting and bearings is important to the uninterrupted and economical operation of any gin and necessitates suitable pedestals or other anchorages. For two-story gins, concrete pedestals are desirable on the ground floor but for one-story or one and one-half-story gins, adjustable iron floor hangers are frequently preferable. Where the shafting is built up of individual lengths coupled together, it is generally advisable that the drive should be made at the center rather than at one end so that torsion and breakage may be minimized.

In making new installations of shafting, belting, and pulleys, an endeavor should be made to eliminate as many drives as possible, because they constitute a possible source of trouble and power loss. Flat belts of adequate center lengths are approximately as efficient as V-belts; but V-belts, when properly selected, can be employed to make very neat, short, safe drives; and under certain circumstances, can be utilized even for right-angle drives.

In selecting either flat or V-belts, the actual load must be kept below the maximum capacity of the belt selected. It is far better to have over-sized flat belts or a few extra V-belts in any drive than to face the delay, expense, and possible damage that might arise through the use of undersized belts. Seasonal service at cotton gins enables operators to use composition beltings of various kinds, but the greatest economy does not necessarily lie in the cheapest belt; and the duty of each drive should be carefully considered in specifying the kind, capacity, and other details of the belt involved.

EFFECTS OF OTHER OPERATING ELEMENTS ON POWER CONSUMPTION

The gin stands themselves may also become a serious source of overloads if operated with a tight roll.[9] Results of numerous tests at the laboratory have shown that by ginning with a tight roll instead of a loose roll, the power requirements increased 50 percent. Results from the survey showed that 64 percent of the gins in the Delta area were operating with a loose roll but 36 percent operated with a medium to tight roll which increased the power loads. This large

[9] BENNETT, CHARLES A., and GERDES, FRANCIS L. EFFECTS OF GIN-SAW SPEED AND SEED-ROLL DENSITY ON QUALITY OF COTTON LINT AND OPERATION OF GIN STANDS. U. S. Dept. Agr. Tech. Bul. 503, 40 pp., illus. 1936.

difference in necessary capacity of the motors or engines required to drive the gins is a material advantage of loose over tight seed-roll ginning. Laboratory tests have shown that varying the saw speed from 100 revolutions per minute below to 100 revolutions per minute above the recommended speed slightly increased the power required by the gin stand, but not enough completely to offset the gains of the increased capacity.

Savings in power can be accomplished in brush gins by properly adjusting the brush settings and speeds. A survey of 32 typical brush gins in the Delta revealed that brush speeds varied from 1,250 to 1,800 revolutions per minute, averaging 1,450 revolutions per minute. At the laboratory, tests have been made to determine the effect of varying the brush speed from 400 revolutions per minute above, and 400 revolutions per minute below the manufacturer's recommendations.[10] These tests showed that by increasing the speed of the brush 400 revolutions per minute above the manufacturer's recommendation, the power to operate the brush was increased 19 percent, or 2.2 horsepower per stand, with no material effect on the doffing action.

SUMMARY

Both laboratory tests and the results of a power survey at 63 representative gins located in the Yazoo-Mississippi Delta showed that it is often advisable to take advantage of each small saving in power and reduced operating costs possible in numerous items in the gin—the sum total of which is frequently considerable. Ginners can effect savings in fan power by lowering fan speeds, repairing fans, reducing separator air losses, correcting the size of cotton-handling pipes, repairing leaky pipe connections, reducing the number of elbows in piping, substituting improved methods of handling seed for unloading fan exhaust blow method, adding control devices and gages on fan inlets for regulating air requirements, and utilizing improved drives and bearings in operating fans. Means for reducing the power requirements of other machine units of the gin include operation with loose seed rolls, avoiding the ginning of damp or wet cotton, feeding cleaners and extractors at uniform rates to prevent chokages and restriction of the cotton therein, delivering a uniform bat of lint cotton to the press, proper adjustment of brush settings and speed, and ginning with loose seed rolls.

The power readings made in this survey showed that on the average about 40 percent of the power used for ginning was consumed by fans and 60 percent by the stands, separators, feeders, cleaners, presses, and other equipment. The average fan in a gin required horsepower per stand as follows: Air-blast fans, 4.7; suction and seed-blowing fans, 5.7; standard suction fans, 4.6; Rembert-type unloading fans, 5.3; seed-blowing fans, 3; drier fans, 3.6; and hull fans, 1.3.

Air readings made at the telescope for the gins in the survey showed that some ginners were moving air at the rate of 6,300 feet per minute and 38 percent of the suction fans surveyed were moving it at the rate of more than 4,000 feet per minute. Laboratory tests have shown that the air velocity at the telescope should be from 3,500 to 4,000 feet per minute for a good suction.

[10] STEDRONSKY, VICTOR L., and JOHNSON, ARVID J. CARE AND REPAIR OF COTTON GIN BRUSHES. U. S. Dept. Agr. Cir. 467, 14 pp., illus. 1938.

Pipe diameters are usually too large. The average suction-pipe diameters for gins in the survey were 11.7 inches for three-stand, 12.3 inches for four-stand, and 13 inches for five-stand gins; whereas laboratory tests have shown that suction pipes of 9 to 10, 10 to 11, and 11 to 12 inches are sufficient to supply three-, four-, and five-stand gins, respectively.

In addition to the fans, another source of power waste in a gin is the separator. From the survey made of 14 gins where the separator loss was 35 percent or more, the power required to operate the suction fan was 27.6 horsepower for a four-stand outfit. In a similar group of 18 gins showing separator losses of less than 35 percent, the fan-horsepower requirements averaged 19.2, which is 8.4 horsepower or 30 percent less than the average for those connected to leaky separators.

Drying fans are also a source of power waste if not properly operated. In installations using the Y-system in connection with the drier set-up, the drier fan used an average of 30.8 horsepower whereas when it was used with a regular suction fan and separator set-up, it used 32.8 horsepower, a saving of 2.8 horsepower for four-stand gins. The saving in total power for these two set-ups for handling the cotton and drying was 2.0 horsepower in favor of the one employing the Rembert fan and Y-system. This does not include the power required to drive the separator.

Many ginners were operating with an overloaded air-blast fan by maintaining a higher nozzle pressure than is necessary for effective doffing as shown in the survey where these pressures ranged from 9 to 19 inches water pressure. Out of the 31 air-blast fans in the survey, 16 were operating with nozzle pressures over 14 inches water pressure or averaging 16.1 inches, and the fans were taking on the average of 21.5 horsepower for a four-stand outfit. The other gins, operated with nozzle pressures of less than 14 inches or averaging 12.6 inches, required for the fans only 16.6 horsepower for a four-stand outfit. This difference of 4.9 in horsepower represents a net saving that can be accomplished by operating at a proper doffing pressure.

Few commercial gins are equipped with variable-speed units or other convenient means for reducing fan speeds to provide the lower volumes that can frequently be used to perform a given task. A cone or slide valve on the intake side of the fan offers an economical and practical means for changing the volume of air without changing the fan speed.

When the discharge from the suction fan is utilized for seed blowing, the power to operate the fan necessarily increases. Tests have shown that such a fan will have to be operated so as to produce a suction velocity of 3,500 to 4,000 feet per minute and a velocity of 5,000 to 5,500 feet per minute in the seed line. The average horsepower required by 15 suction and seed-blowing fans in the survey which were operating with more than 5,500 feet per minute in their seed-blowing line was 26.6 as compared with 18 horsepower for 16 other similar set-ups where less than 5,500 feet per minute was moved, showing a difference of 8.6 horsepower.

Results from the survey of power requirements for 13 typical seed-blowing fans showed that the average horsepower for the 7 gins in this group, using seed-blowing lines of 11 inches or less, was 9.2 as compared with an average of 14.4 for the other 6 gins where seed-blowing lines were larger than 11 inches.

Savings in power can be accomplished in brush gins by properly adjusting the brush settings and speeds. The gin stands themselves may also be a source of overloads in ginneries if operated with a tight seed roll. Results from the survey showed that 36 percent of the gins in the Delta area were operating with medium to tight rolls. Numerous tests at the laboratory have shown that by ginning with a tight roll instead of a loose roll the power requirements increased 50 percent over that required when ginning with a loose roll.

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